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UNITED STATES BUREAU OF MINES
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METHOD AND COST OF MINING TUNGSTEN ORE AT THE NEVADA-MASSACHUSETTS CO. MINES, MILL CITY, NEVADA.

BY

OTT F. HEIZER

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METHOD AND COST OF MINING TUNGSTEN ORE AT THE NEVADA-MASSACHUSETTS CO. MINES, AT MILL CITY, NEV.[1]

By Ott F. Heizer[2]

INTRODUCTION

This paper describing the mining practices at the mines of the Nevada-Massachusetts Co., Inc., at Mill City, Nev., is one of a series being prepared by the Bureau of Mines on mining practices, methods, and costs in the various mining districts of the United States.

The author acknowledges the assistance of William O. Vanderburg, associate mining engineer, U. S. Bureau of Mines, in the preparation of this paper.

The tungsten deposits of the Nevada-Massachusetts Co. are situated about 8 miles northwesterly from Mill City, in Pershing County, Nev. Mill City is on the main line of the Southern Pacific Railroad, about 25 miles from Winnemucca. The mines lie at an elevation of about 5,500 feet above sea level on the east slopes of the Eugene Mountains. The climate and topography offer no difficulties to mining operations.

HISTORY

The tungsten deposits were discovered in 1917, and the immediate production was shipped to Toulon, a custom reduction plant situated on a siding of the Southern Pacific Railroad, 14 miles west of Lovelock, Nevada.

In 1918 the two companies operating in the district, the Nevada-Humboldt Tungsten Mines Co. and the Pacific Tungsten Co., each built a mill. Both mills went into operation in October.

After operating several months the mines and mills were forced to close down, as the great demand for tungsten in the manufacture of munitions ceased when the Armistice was signed. The stocks which foreign producers had accumulated were available at a low price for peace-time needs. The mines remained idle for six years, or until 1924, when the Pacific Tungsten Co. mine was operated under lease. The mines were again able to resume production because of the fact that, by the tariff act of 1922, imported tungsten was subject to a duty of 45 cents per pound on the tungsten content of the ores.

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2 Consulting Engineer, U. S. Bureau of Mines.

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In 1926 the Nevada-Massachusetts Co. took over the Pacific Tungsten Co. and later acquired the Humboldt property. This company has been the largest producer of tungsten ore in the United States for the past three years. At present the company employs about 70 men and produces 142 tons of scheelite ore per day, containing an average of 1.10 per cent scheelite or 0.9 per cent tungsten trioxide.

PRODUCTION

The production of tungsten ores from the Mill City district, from the date of discovery to the end of 1928, has been as follows:

Company	Year	Tons of Ore Produced	Grade of Ore, % WO_3
Nevada-Humbolt Tungsten Mines	1917	8000	1.5
Pacific Tungsten Co.	1917	7000	1.85
Nevada-Humboldt Tungsten Mines	1918	15000	.71
Pacific Tungsten Co.	1918	5500	1.30
Pacific Tungsten Co.	1924 1925	20000	1.50
Nevada-Massachusetts Co.	1926	25662	1.00
Do.	1927	25424	1.12
Do.	1928	40924	.96

The tonnage and grade of the ore previous to 1926 have been estimated from information obtained from the most reliable sources available. The grade of concentrate produced at Mill City averages about 72 per cent tungsten trioxide; it is often as high as 76 per cent. Chemically pure scheelite contains 80.6 per cent tungsten trioxide. (According to Dana, scheelite: $CaWO_4$. tungsten trioxide, 80.6 per cent; lime, 19.4 per cent.) The concentrates are shipped to Pittsburgh or Niagara Falls to be reduced in the electric furnace with iron to form ferrotungsten with a tungsten content ranging from 50 to 80 per cent. This is purchased by the steel makers and added to steel to form the desired grades of tungsten steel.

GEOLOGY

The geology and mines of the Mill City District have been described by Frank L. Hess and Esper S. Larsen.[3]

3 Hess, Frank L. and Larsen, Esper S., Contact-Metamorphic Tungsten Deposits of the United States: U. S. Geol. Survey Bull. 725-D, 1922, pp. 245-309.

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The formation in the Mill City district comprises a series of sedimentary rocks consisting of shales, sandstones with intercalated beds of limestone, and quartzite. The sediments were disturbed by folding and faulting, and in the vicinity of the mines they were tilted at an angle of 75°. The folded and faulted sedimentary strata were intruded by a granitic magma which altered the sediments to hornfels. In places the limestone beds have been altered to marble and tactite. The latter is a highly complex metamorphic rock containing at Mill City scheelite and at least 17 other minerals.

Although the deposits are termed contact-metamorphic, the ore occurs not only at the actual contact of the granite and the limestone but also in the limestone beds, in some cases 2,000 feet from the granite. Two of the limestone beds have been developed - the Sutton and the Stank - which were named after the original owners. The Sutton bed is the less important of the two, averaging about 3 feet in width, and it is less altered than the Stank. In several places the Sutton bed is mineralized up to a width of 45 feet. The mineralization in such cases, however, is not sufficient to make commercial ore at the present price of tungsten, as the beds carry only ½ of 1 per cent tungsten trioxide. The Stank bed has been the most productive; it is exposed for a length of 1 mile, although the continuity of the bed is interrupted in places by erosion of the sediments, exposing the underlying granite. The Stank bed has an average width of 4½ feet, an average dip of 75° to the west, and a general strike of N. 10° E. The bed has been displaced from 3 to 60 feet in places by postmineral faults. As the faults so far encountered are all normal, with one exception, it is usually not difficult to locate the bed beyond a fault.

In general, the beds that dip at a high angle are well adapted to the shrinkage stope method of mining. The walls of the beds stand with a moderate amount of support and the ore breaks well.

METHODS OF PROSPECTING AND EXPLORATION

Scheelite was first discovered in the district by prospectors who were panning the gulches for gold. The source of the scheelite grains found in the pannings was traced to an outcrop of what is now called the Stank bed. Scheelite does not alter readily, so that surface indications of enrichment at the outcrop were entirely absent.

The beds were explored, where the nature of the topography permitted, by driving adits along the strike of the beds. As the ore was followed to depth the beds were further explored by shafts sunk on the dip. Drifts were driven from the inclined shafts at intervals of 100 feet measured on the dip.

In drifting, faults cutting the beds at very acute angles have caused difficulty in exploratory work; in several instances these strike faults have been taken as the foot wall of the beds and the drifts extended along them for a considerable distance before the faults were recognized as such. To minimize the possibility of drifting on these faults and to assure that the bed is being followed, one lifter of each drift round is drilled in the footwall waste rock.

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METHOD OF SAMPLING

A rapid and reliable method has not been devised for assaying scheelite ores similar to those which occur at Mill City, so that the mine samples are not determined by analytical methods. However, the samples taken are panned, and in the hands of an experienced operator the results obtained by panning are very reliable.

Estimates of ore reserves are not made because of the wide variation in the distribution of scheelite in the ores and the excessive amount of development work and sampling that would be required to make reliable estimates.

MINE DEVELOPMENT

Shafts

The two main shafts on the Nevada-Massachusetts property are the Stank shaft, 730 feet deep, and the Humboldt, 620 feet. The Humboldt shaft is being deepened at the present time. Both of the shafts are on the Stank bed. Each shaft is 9 feet 6 inches by 5 feet 2 inches outside the timbers and is divided into two compartments. The hoisting compartment is 4 feet 6 inches by 4 feet in the clear and the manway 3 feet 6 inches by 4 feet. The footwall plate, divider, and end plates are 6 by 6 inch timbers. The hanging-wall plate for a set consists of a 6 by 8 inch timber to furnish additional strength to carry the weight of the ore pocket. The halved method of joint framing with the bevel hitch is employed. The bevel is used to prevent the timber from splitting and to increase the strength of the joint.

The track for the 1-ton skip in each shaft consists of 16-pound rails; the gage is 33 inches. Rails are spiked to the footwall plates, except at the stations, where they are placed on 6 by 10 inch stringers placed lengthwise with the dip of the shaft.

In sinking the Humboldt shaft two men are employed on contract, working one shift per day. Development work is far enough in advance of actual mining operations so that speed is not essential. The contract price for sinking this shaft, which is dry, is $15 per foot; the contractors drill and blast the rounds, shovel the broken material into a sinking bucket, and place timbers. All supplies are furnished by the company, as well as the hoistman to operate the sinking bucket. About one shift is required for breaking, one shift for shoveling, and one shift for placing two sets of timbers. The Stank shaft, which is wet at the lower levels, is sunk on three shifts on contract. The contract price is $25 per foot for labor only.

The bucket used in sinking is 24 inches in diameter and 30 inches high and has a capacity of about 600 pounds. The self-dumping arrangement of the sinking bucket is shown in Figure 1. The skids are 4 by 6 inch timbers placed 18 inches apart. Lugs are provided on the bucket below the center of gravity. In raising or lowering the bucket the lugs do not touch the skids, except at the dumping place, where the width between the skids is increased to allow the lugs to

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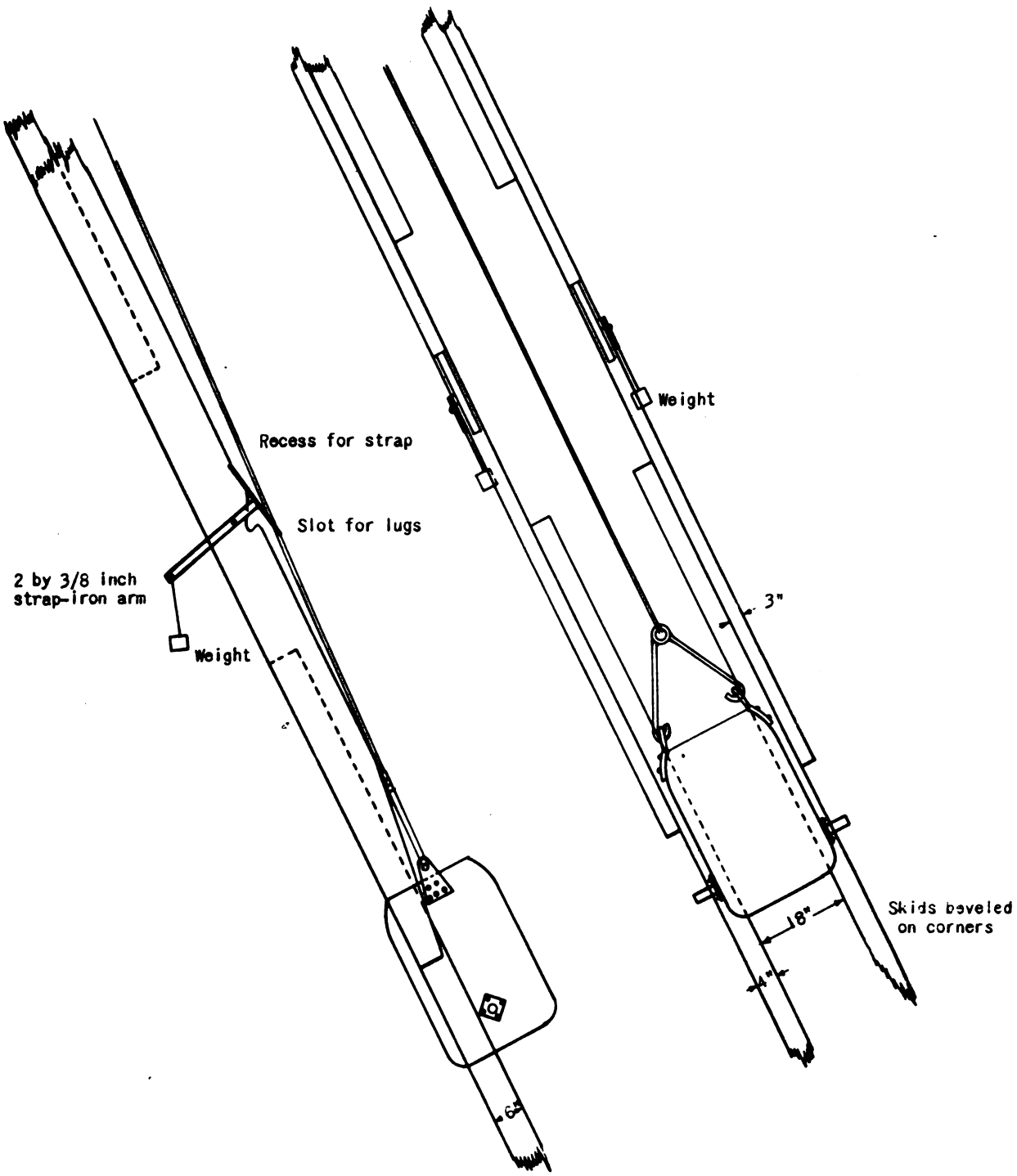

Figure 1.- Sinking-bucket dumping arrangement

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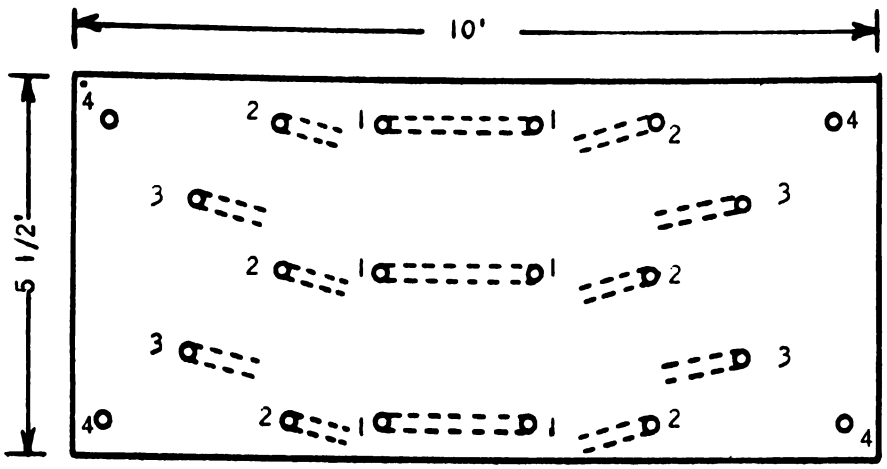

Figure 2A .- Twenty-hole shaft round. Numbers indicate order of firing

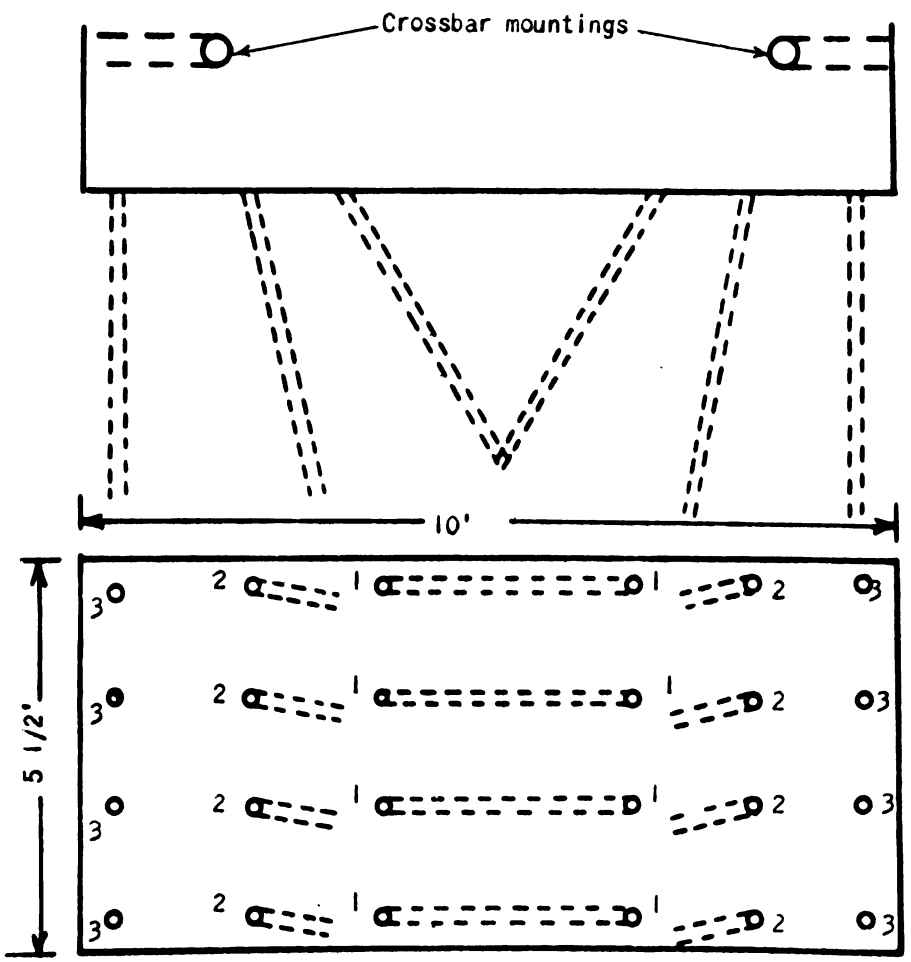

Figure 2B.- Twenty-four-hole shaft round. Numbers indicate order of firing

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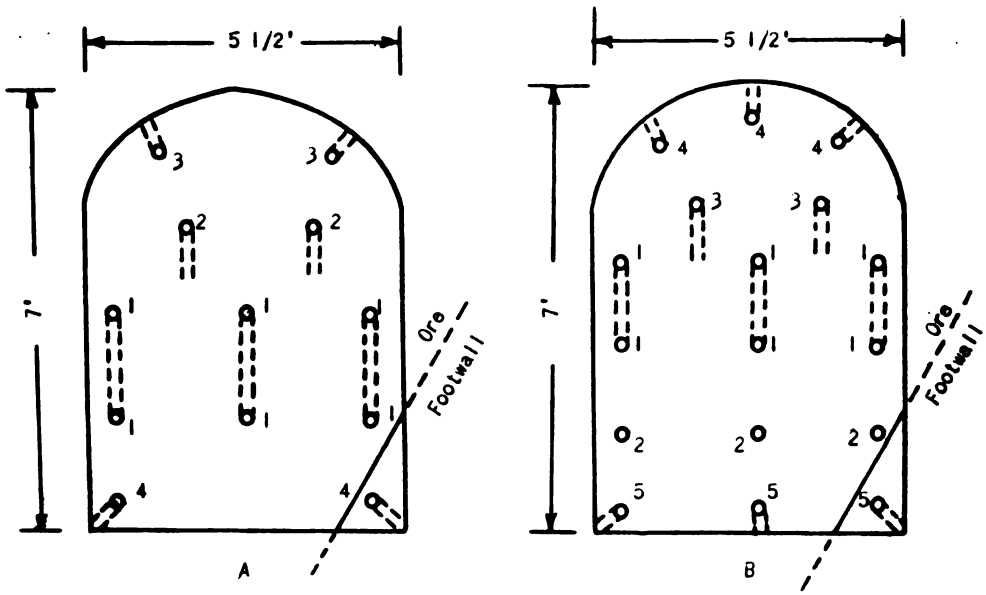

Figure 3.- A, Twelve-hole drift round; B, seventeen-hole drift round. Same rounds used for crosscuts. Numbers indicate order of firing

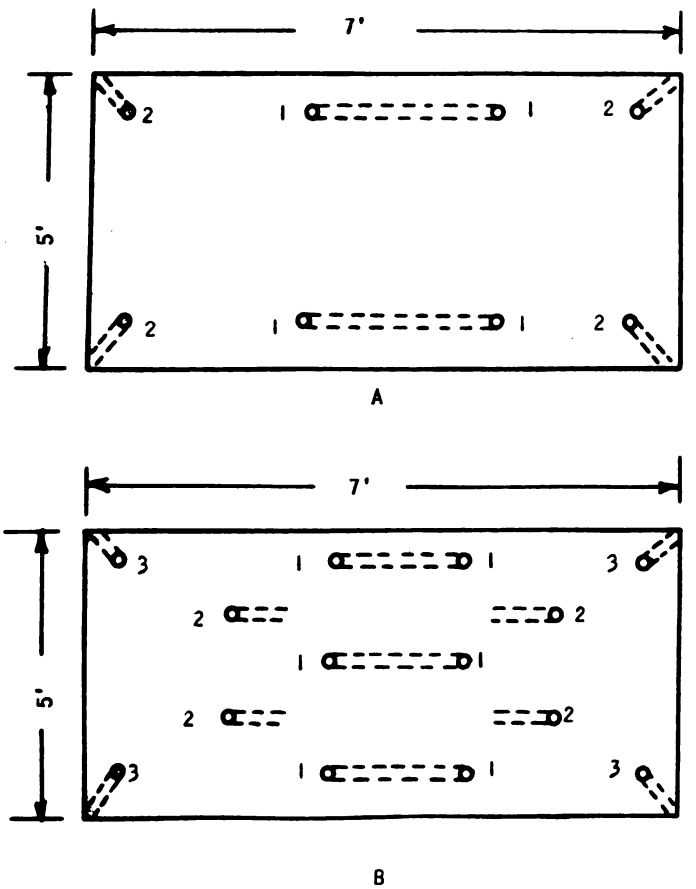

Figure 4.- Fourteen-hole raise round. Numbers indicate order of firing

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drop into the notches cut in the skids as the loaded bucket is raised. By releasing the tension on the hoisting rope the bucket overturns, and the T-shaped arms made of 2 inch by 3/8 inch strap iron permit the lugs to slide under the straps when the bucket is raised, and over the straps when the bucket is lowered. The bucket is operated in the manway side of the shaft. To protect the men working in the bottom of the shaft from falling material a bulkhead of round timbers 8 inches in diameter is placed 30 feet below the level.

A small, portable, double-gear-reduction 7 1/2-horsepower electric hoist, with the motor inside the drum, is used in sinking. The hoist is mounted on the level directly above the place where sinking is in progress.

An ordinary shaft round consists of 20 holes 5 feet deep, as shown in Figure 2-a. If the ground is unusually hard 24 holes are required to break a round drilled 5 feet deep. This round is shown in Figure 2-b. The 20-hole round is drilled with jackhammers using 1-inch hollow hexagonal steel, and the 24-hole round is drilled with leyner machines mounted on either a crossbar or a crossarm attached to the crossbar. With the leyner machines 1 1/4-inch hollow round steel is used. In some of the hardest ground encountered as many as 240 pieces of steel have been used to drill a 24-hole shaft round.

Both the jackhammer and the leyner steel have the usual double-taper cross bit. The steel lengths and the bit gage for each length are as follows.

Length, feet	Jackhammer steel, bit gage, inches	Leyner steel, bit gage, inches
1 1/2	2	2 1/4
1 1/2 to 2 1/2	1 7/8	2
2 1/2 to 3 1/2	1 3/4	1 7/8
3 1/2 to 4 1/2	1 5/8	1 5/8
4 1/2 to 5 1/2	1 1/2	1 1/2
5 1/2 to 6 1/2	1 3/8	1 3/8

Forty per cent strength gelatin dynamite is used in shaft sinking. No. 6 electric delay detonators are used, which are fired with the electric light circuit of 110 volts.

Drifts and Crosscuts.

Drifts and crosscuts are driven 5½ feet by 7 feet in cross section and are untimbered. Ordinarily one miner drills and blasts a round consisting of 12 to 17 holes in one shift. The 12 and 17 hole rounds are shown in Figures 3-a and 3-b. The broken material from a round is shoveled into 16-cubic foot cars and trammed to the nearest dumping place underground by one man working on the opposite shift. The development work is so planned that most of the waste rock can be disposed of underground for filling mined out stopes. The routine of operations in advancing a drift or crosscut is as follows:

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Miner (1) day shift		Mucker (1) night shift	
Operation		Operation	
Barring down	1/4 hr.	Cleaning track	1 hr.
Getting equipment to face	1/2 hr.	Barring down	1 hr.
Setting up	3/4 hr.	Mucking and tramming	5 hrs.
Drilling	4 hrs.	Place shoveling sheets	1/4 hr.
Tearing down	1/2 hr.	Picking down face	1/4 hr.
Moving equipment	1/2 hr.		
Loading holes	3/4 hr.		
Blasting	1/4 hr.		

The average tramming distance is about 300 feet. The temporary track, which consists of short sections of rail secured to steel ties, is placed by the mucker; permanent track is laid by the mucker if he has time to do so or by a timberman if the mucker has not the opportunity. The steel shoveling sheets are 3 by 4 feet 3/16 inch thick.

A drift round is drilled with a leyner machine mounted on crossarm [illegible] attached to a column. Forty per cent strength gelatin dynamite is used, detonated with No. 6 detonators attached to fuse.

Drifts and crosscuts are usually driven on company account. Exceptionally wet places are contracted at a rate of about $5 per lineal foot for mucking and breaking. A contract crew consists of two men - one man on each shift. The contract is usually given for 100 feet and 20 per cent of the contract price is held back until the contract is completed as a guarantee for fulfilment of the contract.

Raises

Raises are 5 by 7 feet in section and are driven for three purposes: (1) For ventilation, (2) for manways to the stopes, (3) and for chutes in drawing ore.

In advancing a ventilation or manway raise one man drills and blasts a round consisting of from 8 to 14 holes as shown in Figure 4-a and 4-b. Practically all raising is done in ore. In addition to the raise round additional slabbing holes are drilled and blasted by the miner on two sides of the raise as the raise is carried upwards. (See manway raise, fig. 5) The extra width affords protection to the raise timbering when blasting near the raise in stoping operations. The staging for drilling is put in by a timber crew of two men on the opposite shift. After two or three rounds have been drilled and blasted in a raise the timber crew places two sets of timber with the necessary lining. Timber for a raise consists of stulls 8 inches in diameter placed on 5 foot 4 inch centers.

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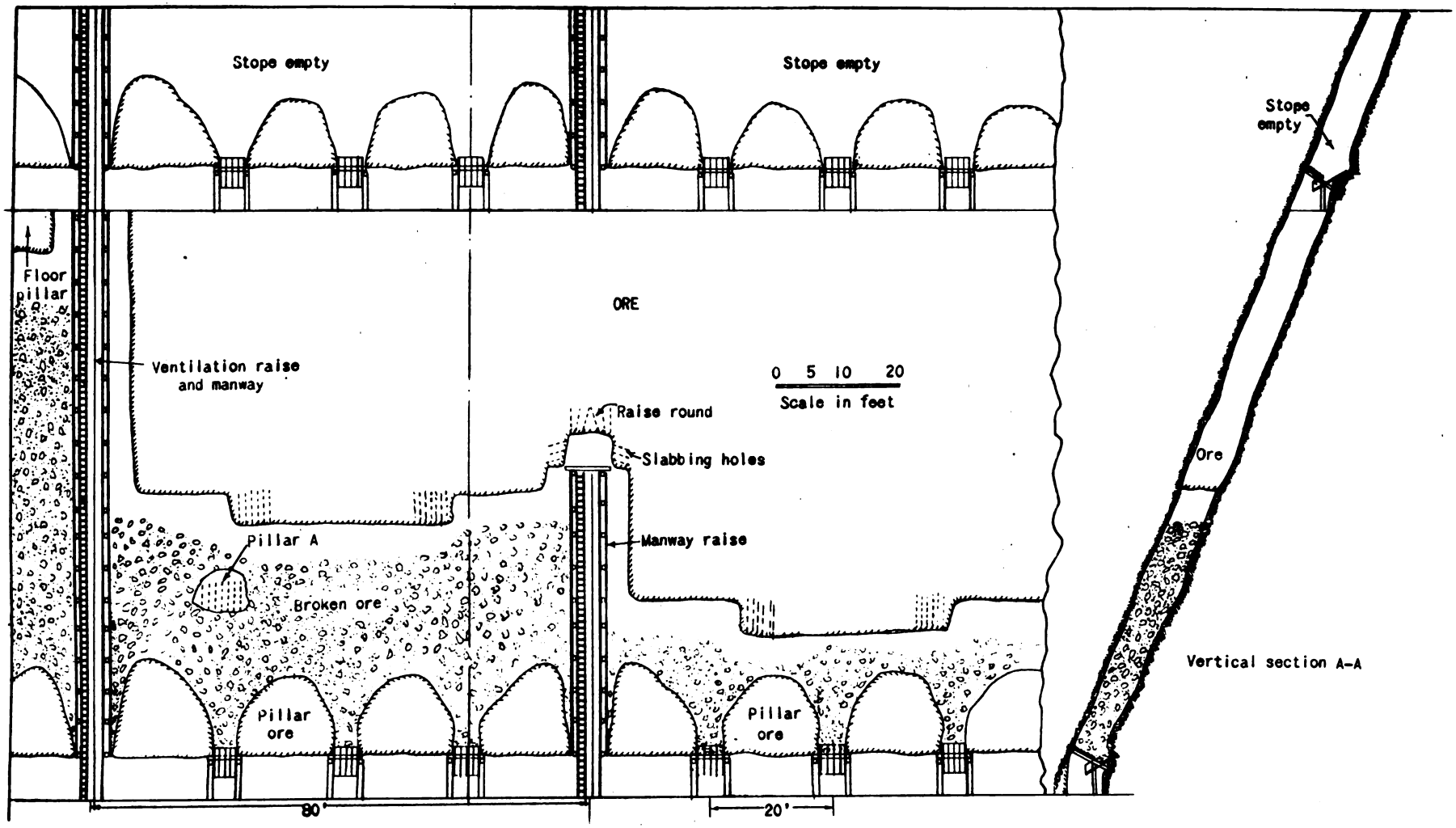

Figure 5.- Longitudinal and vertical section of stope

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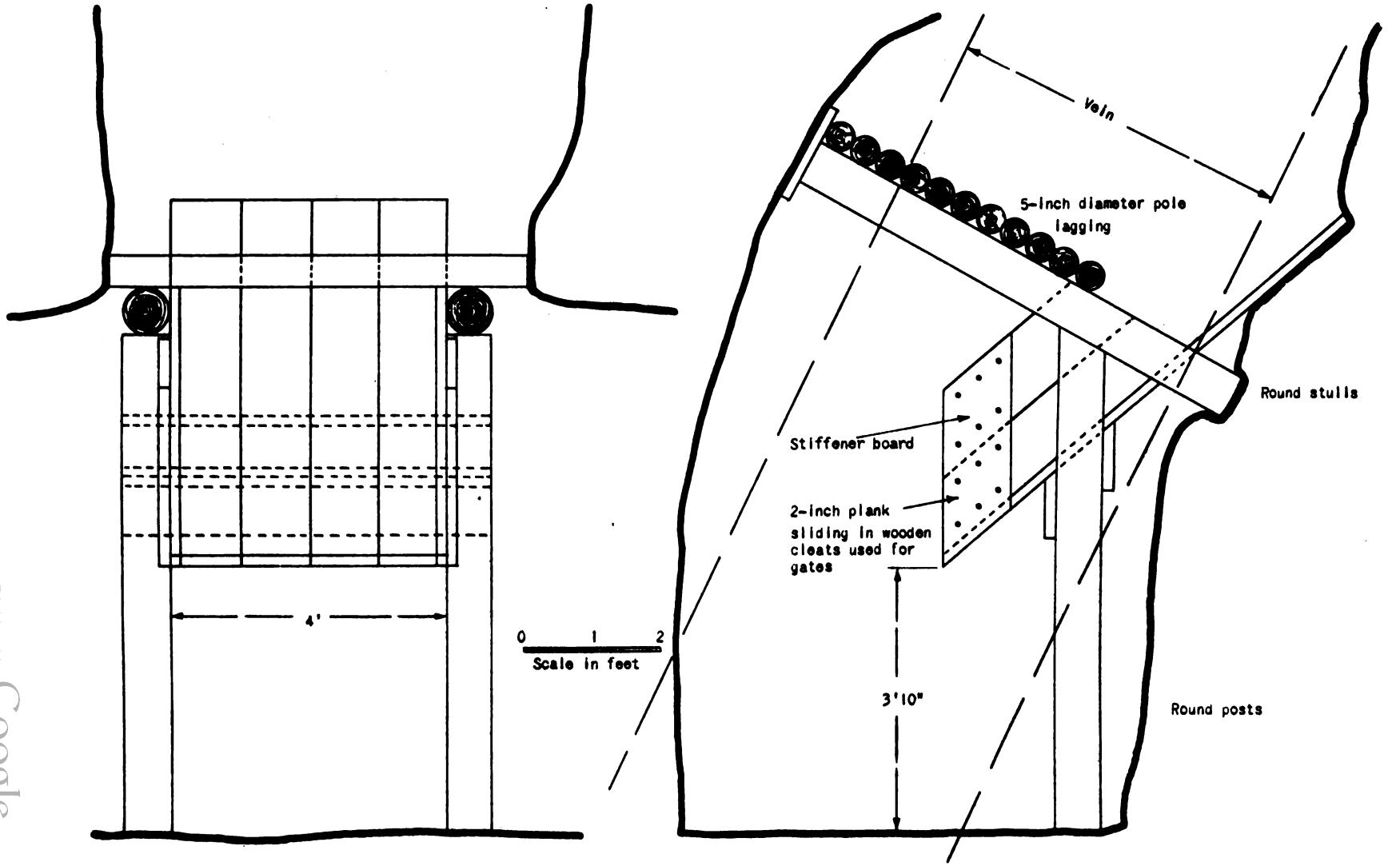

Figure 6.- Standard chute timbering

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This spacing of stulls has been adopted so that the 2 by 12 inch planks 16 feet long used for lining may be cut in 5 foot 4 inch lengths without any waste. Manways and ventilation raises, which are used for manways, are single-compartment, 4 feet wide in the clear. Each manway is equipped with a ladderway and timber slide. The timber slide consists of 2 by 12 inch planks; one side of the slide is formed by the ladder and the other by a 2 by 4 nailed to the side of the plank. Supplies are hand-hoisted to the top of a raise by means of a single pulley block and hemp rope. The block is chained to a length of drill steel placed over the stulls at the top of the raise. The routine of operations in driving a raise is about as follows:

Miner (1) day shift		Timbermen (2) night shift	
Operation	Time	Operation	Time
Getting equipment on drilling platform ..	1 hr.	Barring down	1 hr.
Preparing to drill ...	1/2 hr.	Hoisting timber	1 hr.
Drilling	4 hrs.	Placing two sets	6 hrs.
Tearing down and removing equipment ...	1 hr.		
Loading	1 hr.		
Blasting	1/4 hr.		

Raises for ore chutes are not timbered. The chute raises are driven 6 feet above the back of the drift at intervals of 15 or 20 feet and then belled out so as to join each other. The chute shown in Figure 6 is built in each raise before the belling out process is started. In driving the chute raises temporary staging is used for drilling when necessary.

Hand-rotated stoper machines with 1 1/8-inch Rocky Mountain pattern, heavy-ribbed, cruciform steel and high-center cross bits, are employed in raising. The steel lengths and bit gage for each length is as follows:

Length, feet	Bit gage, inches
1 1/2	1 15/16
1 1/2 to 2 1/2	1 7/8
2 1/2 to 3 1/2	1 3/4
3 1/2 to 4 1/2	1 5/8
4 1/2 to 5 1/2	1 1/2

Forty per cent strength gelatin dynamite is used with No. 6 detonators and fuse.

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STOPING

All the ore is mined by the shrinkage-stope system without filling except for disposing of waste from development work. The bed, which has an average width of 4½ feet, is mined in sections having a length of 75 or 80 feet. (Figure 5.)

In preparing a block or section for mining the bed is first exposed by drifting. After this has been done a ventilation raise is driven to the level above as far from the shaft as possible. While the ventilation raise is being driven chute raises are driven at intervals of 15 or 20 feet and chutes installed. A manway to afford access to the stope is started 80 feet from the ventilation raise if the chute spacing is 20 feet and 75 feet from the ventilation raise if the chutes are spaced on 15-foot centers. The chute interval is determined by the character of ore; if the ore is dry and can be drawn readily without hanging up the 20-foot spacing is used; if the ore is damp and has a tendency to chimney or hang up the 15-foot interval is chosen. An effort is made to draw the excess broken ore from the stopes uniformly and this is accomplished with damp ore by close spacing of raises.

After the ventilation raise has been driven to the level above, the chutes built, and the chute raises belled out to connect with each other and the manway at the other end of the block started, stoping operations are begun.

The stope is advanced as a single face by means of horizontal slices drilled with leyner machines if the ground is hard, or by vertical slices with hand-rotated stoper machines if the ground is comparatively soft. Two miners are employed in a stope block who advance toward each other, one starting at the ventilation raise, which is also used as a manway, and the other at the manway at the other end of the block. When the cut is completed other slices are taken in the same manner. The excess broken ore is drawn off as stoping progresses, so that a distance of 6 feet is maintained between the top of the broken ore and the back of the stope. The manway is raised from time to time as the stope is carried upward.

Loose spots are encountered in the hanging wall as stoping progresses, and to prevent dilution these are supported with 8-inch stulls and 3 by 12 inch headboards 18 inches long. If the stulls are not sufficient a pillar of ore may be left in the stope, which is drilled so that it may be blasted later when the block is stoped and the ore is being withdrawn. (Figure 5, at "A".)

The stope is advanced to within 6 feet of the floor of the level above, under which a floor pillar is left until the operations on the level are completed, when the pillar will be removed by underhand stoping if the stope is filled with waste; or, if the stope is empty, it will be blasted down and the ore drawn off at the level below.

In drawing the ore from a completed stope the top of the ore is followed downward by timbermen, who catch up any loose spots in the walls and trim off any ore that may have been left as the stope was carried upward.

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The stoper round is shown in Figure 7. About 14 holes, 5 feet deep are drilled per man per shift. The leyner stope round is shown in Figure 8. About 5 holes, 6 feet deep are drilled with a leyner machine per man shift in stoping. One and one-eighth cruciform steel is used with the stopers and 1¼-inch round with the leyners.

Gelatin dynamite of 35 per cent strength is used in stope blasting. No. 6 detonators and fuse are used for making primers. No stemming is used.

TRANSPORTATION

All tramming underground is done by hand with 16-cubic foot roller-bearing end-dump cars, which hold about 1 ton of ore each. The maximum tramming distance underground is about 600 feet. The ore is drawn from the stopes through chutes equipped with plank gates sliding in wood cleats nailed to the sides of the chutes. The ore is dumped into the shaft skip pockets, which hold about 60 tons each. The pockets have grizzlies with 8-inch openings made of 30-pound rails placed with the flat side up, so that the oversize material does not wedge between the rails.

From the skip pockets the ore is drawn through rack and pinion gates into 1-ton skips and dumped into the surface ore bins. At the Stank shaft the ore is trammed from the shaft bin to the gravity tram bin, a distance of 800 feet, and then lowered in end-dump skips to the narrow-gage railroad bin for transportation to the mill. At the Humboldt shaft the ore is dumped from the skip directly into the railroad bin.

The track in the mines consists of 16 pound rails laid with an 18-inch gage on a grade of ¾ of one per cent in favor of the loaded cars.

The ore is hauled from the mine railroad bins to the mill by an 8-ton gasoline locomotive. One man loads and dumps cars, operates the locomotive, and looks after the equipment. The surface cars have a capacity of 67½ cubic feet or about 5 tons each. The cars are of the gable-bottom side-dump type, equipped with roller bearings and chilled wheels 14 inches in diameter. A train consists of 5 cars. The track consists of 30-pound rails laid on an average grade of 4 per cent in favor of the loaded trains. The steep grade on the surface track is due to the nature of the topography and the location of the mill. Ties are 4 by 6 inches, 4 feet in length, spaced on 2-foot centers.

The cost of transporting ore from the mines to the mill per ton-mile is as follows:

Labor (one man at $6 per day)	$6.00
Gasoline per day	3.00
Oil and other expenses	1.00
Total	$10.00
Average distance of haul	2 miles
Tons hauled per day	142
Ton miles per day	284
Cost per ton mile	$0.035 [1]

[1] Depreciation not included.

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Each shaft is equipped with a double-gear-reduction single-drum hoist and 7/8-inch, 6-strand, 19-wire, hemp-core, plow-steel hoisting rope. Each hoist is driven by a 52-horsepower, variable-speed, 440-volt alternating-current motor. Hoisting speed is about 300 feet per minute.

PERCENTAGE OF EXTRACTION

The extraction of ore is about 95 per cent. The dilution from sloughing of wall rock is estimated at 20 per cent. About 35 per cent of the ore is drawn off as stoping progresses. Hand sorting is not practiced, as the ore drawn from the stopes is covered with mud so that prior washing would be necessary.

WAGE SCALE

About 80 per cent of the underground employees are American born and the remaining 20 per cent of various European nationalities. The labor turnover is very small. Periods of one month have been observed without a single change in the payroll names. The wage scale as of December, 1929, for the principal classifications of mine employees was as follows:

Blacksmith	$6.50
Blacksmith helper	5.25
Hoistman	6.00 and 5.75
Mucker	4.75
Motorman (surface)	6.00
Miner	5.25
Pumpman	5.25
Topman	4.75
Skiptender	5.25
Timberman	5.25

PUMPING

About 90 gallons of water per minute are pumped from the Stank mine. The water is pumped to the surface in two lifts, one of 200 feet and the other of 480 feet. For the 200-foot lift the water is pumped by one single-stage 2-inch centrifugal pump; for the 480-foot lift two 2-inch single-stage centrifugal pumps are used, which are operated in tandem. Each pump is direct-connected to a 20-horsepower, 3,600-r.p.m., 440-volt alternating-current motor. The pumps are started and stopped by an automatic float control. To keep the pumps primed a $\frac{1}{4}$-inch by-pass line from the pump column to the pump with a check valve on the pump discharge line is employed. The column capacity is sufficient to keep the supply of water running into the pump during the time that the pump is idle. With this arrangement there is little danger of the pumps not taking the water when they are automatically started.

Sumps are cut in ore as each new level is being opened. By cutting the sumps in ore the cost of excavating in waste rock is avoided.

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VENTILATION AND FIRE HAZARD

Ventilation is natural, and the mine is cool the year around. With the shrinkage-stope method of mining the amount of timber used is very small, so that the fire hazard is not great. The mine is kept clean at all times, and all rubbish hoisted to the surface.

Table 1. - Summary of Costs

Nevada-Massachusetts Co. mines. Year 1928

Tons of ore hoisted: 40,924 Mining method: Shrinkage

Underground costs per ton of ore hoisted. (1)

	Labor	Supervision	Drills & Steel	Power	Explosives (2)	Timber	Other supplies	Total
Development (3)	$0.557	$0.012	$0.025	$0.092	$0.100	$0.036	$0.085	$0.907
Mining	1.662	.064	.100	.309	.355	.146	.207	2.743
Pumping	.050	- -	- -	- -	- -	- -	.055	.105
Transportation (4)	.053	- -	- -	- -	- -	- -	.137	.190
Total	2.322	.076	.125	.301	.455	.182	.484	3.945

Note: Above costs are direct costs only.

(1) About 15,000 additional tons of ore was broken and not hoisted during 1928.
(2) Powder, fuse, and caps.
(3) In ore and rock.
(4) Surface tram to mill only; underground tramming costs included in mining and development labor.

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Table 2. - Summary of Costs in Units of Labor, Power, and Supplies

Nevada-Massachusetts Co. mines. Year 1928

Tons of ore hoisted: 40,924 Mining method: Shrinkage

	Development	Mining	Total
A. Labor (man-hours per ton)			
Breaking (drilling and blasting)	$0.183	$0.700	$0.883
Timbering	.053	.376	.429
Shoveling and tramming	.167	.383	.550
Shaft sinking	.098	- -	.098
Hoisting	.136	.552	.688
Supervision	.040	.168	.208
Pumping	- -	- -	.195
Total labor underground	.677	2.179	3.051
Average tons per man per shift			2.62
Average tons per man per shift on surface properly chargeable to underground operations			56.06
Labor per cent of total cost			56.02
B. Power and supplies			
Explosives			
Sticks per ton	0.316 (1)	4.648 (2)	4.964
Pounds per ton	.139	1.650	1.789
Caps No. 6, number per ton	.23	1.02	1.25
Fuse, feet per ton	1.29	6.13	7.42
Timber			
Sawed stock, bd. ft. per ton	.73	2.90	3.63
Poles, lin. ft. per ton	.12	.49	.61
Power, kw.-hr. per ton	3.25	7.23	10.48
Other supplies in percentage of total power and supplies			21.5
Supplies and power per cent of total cost			43.98

(1) 40 per cent gelatine size 1 1/8 by 8 inches.
(2) 35 per cent gelatine size 1 by 8 inches.

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Table 3. - Details of Costs in Units of Labor, Power, and Supplies

Development				Year 1928	
	Shafts	Drifts	Crosscuts	Raises	Total
Number of feet	101	1855	90	192	2238
Size of excavation	5½ x 10	5½ x 7	5½ x 7	5 x 7	- -
Timbered or not	Yes	No	No	Yes	- -
Rock	Quartzite	Ore and marble	Quartzite	Ore	- -
A. Labor (man-hours per foot)					
Breaking (drilling and blasting)					3.350
Timbering					.969
Shoveling and tramming					3.053
Shaft sinking					1.791
Hoisting					2.486
Supervision					.731
Total labor					12.376
Feet per 8-hour shift					0.646
B. Power and Supplies					
Explosives:					
Sticks per foot 40 per cent gel.					5.78
Pounds per foot					2.54
Caps No. 6, number per foot					4.20
Fuse, number of feet per foot					23.50
Timber					
Sawed stock, bd. ft. per foot					13.34
Poles, 8 inches diameter, linear feet per foot					2.19
Power, kw.-hr. per foot					5.94
Other supplies, per cent of total power and supplies.					32.5
C. Labor, per cent of total cost					62.7
Power and supplies, do.					37.3

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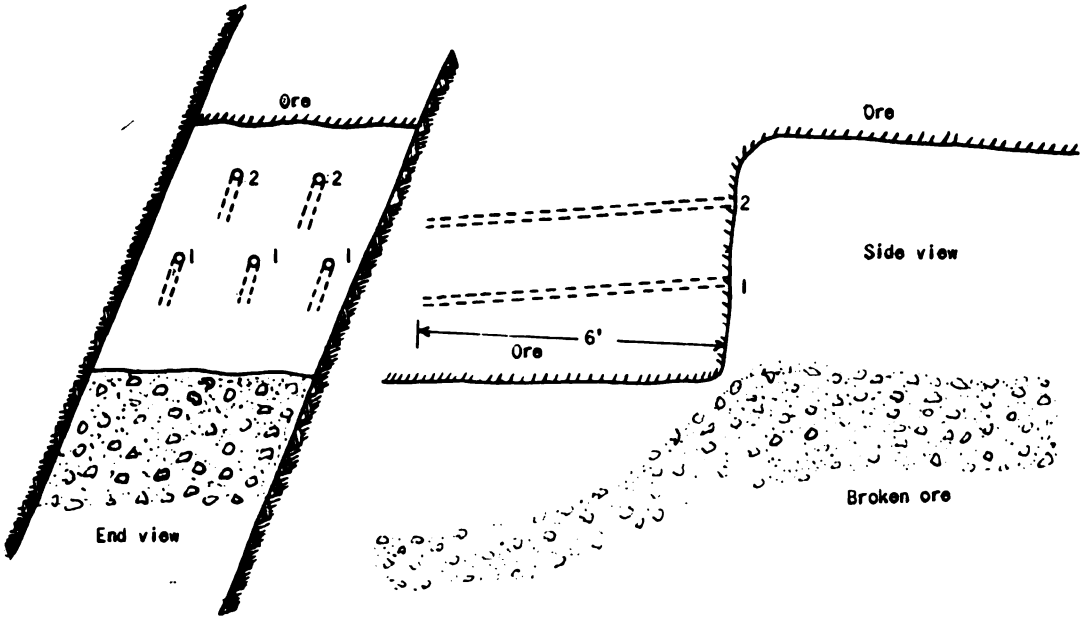

Figure 8.- Five-hole stope round in hard ore. Numbers indicate order of firing

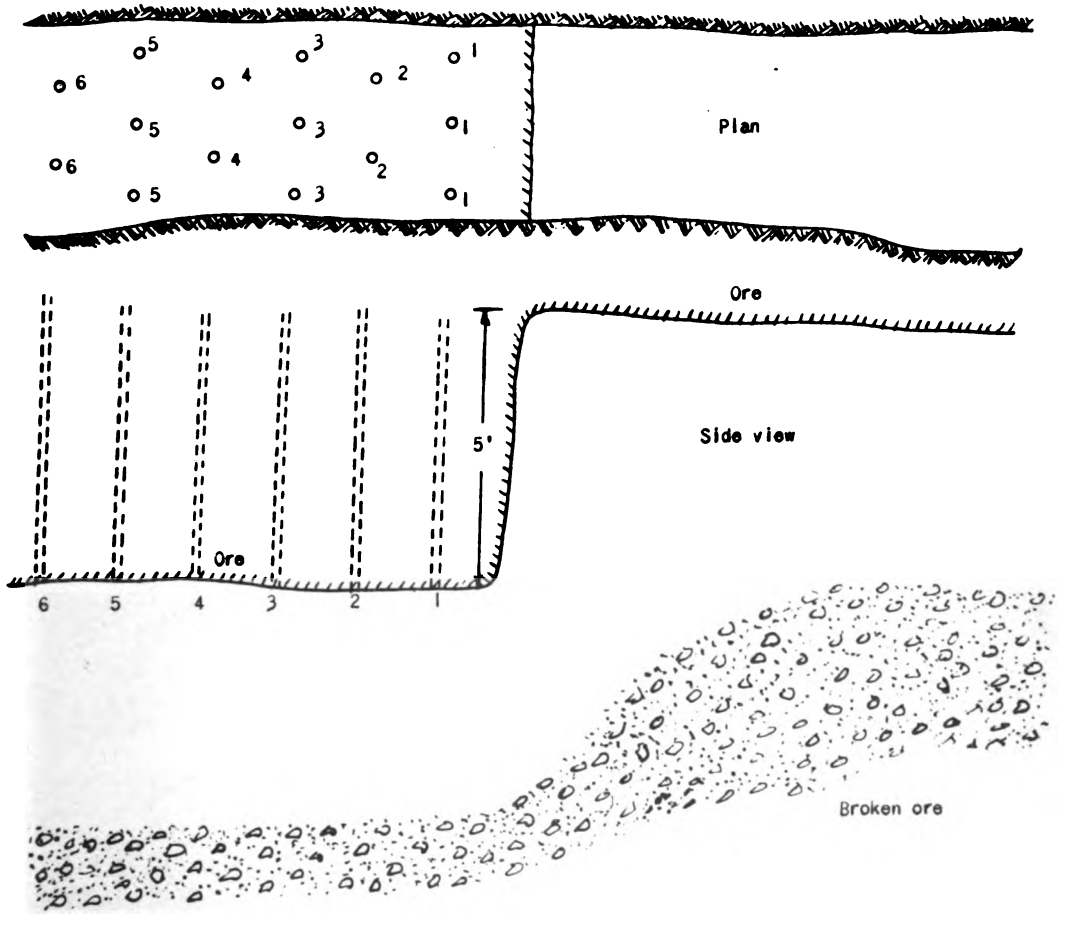

Figure 7.- Fifteen-hole stope round in soft ore. Numbers indicate order of firing

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